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Seismic Response Analysis of Long Immersed Tunnel to Longitudinal Non-uniform Excitation

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Recent observations have showed that the motions at different supports of a long tunnel can be quite different during an earthquake. The main reasons of such differences include the wave passage effect, the local site conditions, and the incoherence effect[1]. Therefore, it is very important to consider the non-uniform earthquake excitation for seismic response analysis of long tunnels.

Seismic response of underground structure essentially depends on the ground motion and its interaction with the structure[2]. Based on these characteristics, a simplified numerical model based on the equivalent mass-spring system[3] is proposed to analyse the seismic response of long immersed tunnel as demonstrated in Fig.1.

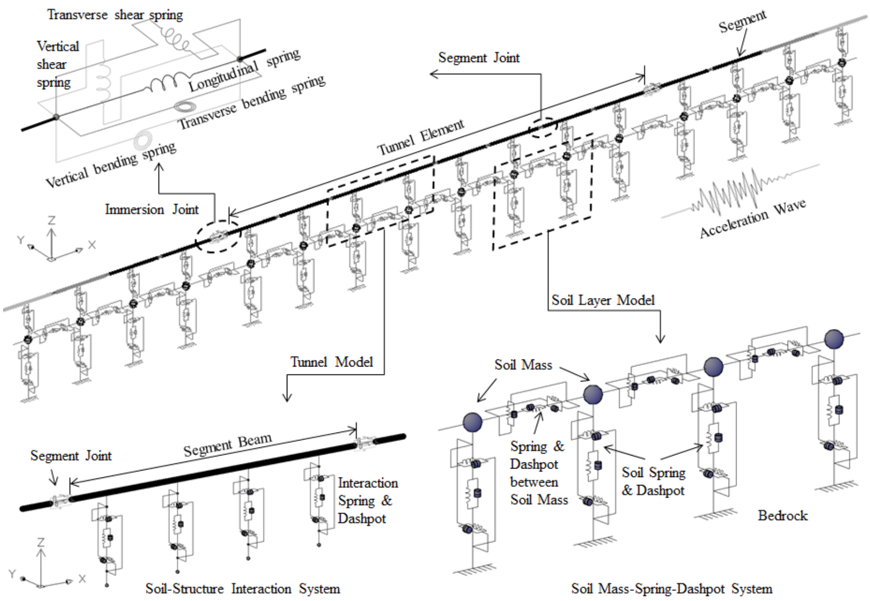

Fig.1 Simplified model for seismic response of immersed tunnels

This analysis model essentially consists of the soil mass-spring-dashpot system and the soil-structure interaction system. The soil mass-spring-dashpot system is derived from the equivalent mass-spring system in which the soil deposit is divided into a number of slices perpendicular to the tunnel axis. Each slice is represented by a mass, a spring and a dashpot whose properties are determined by the first mode of shear vibration of the slice. The tunnel is assumed as an elastic beam supported on a viscoelastic foundation in the soil-structure interaction system. The determination of the interaction impedances refers to the works of Gazetas[4]. Simultaneously, the immersion joint, which consists of a flexible Gina gasket and the shear keys, is represented by a group of five nonlinear springs, i.e. longitudinal, transverse shear, vertical shear, transverse bending, and vertical bending components. Furthermore, the input of uniform or non-uniform (time lag) excitation can act on the bedrock.

Fig.2 illustrates the results of the 6km long immersed tunnel of Hong Kong-Zhuhai-Macao Link subjected to different modes of earthquake motions. It can be obtained from the figure that the longitudinal seismic deformation of the immersion joints is significantly affected by the non-uniform excitation. Compared with the uniform excitation, the deformation range of immersion joints is larger in the non-uniform excitation cases. In addition, the results obtained from the numerical model are also influenced by the wave propagation directions.

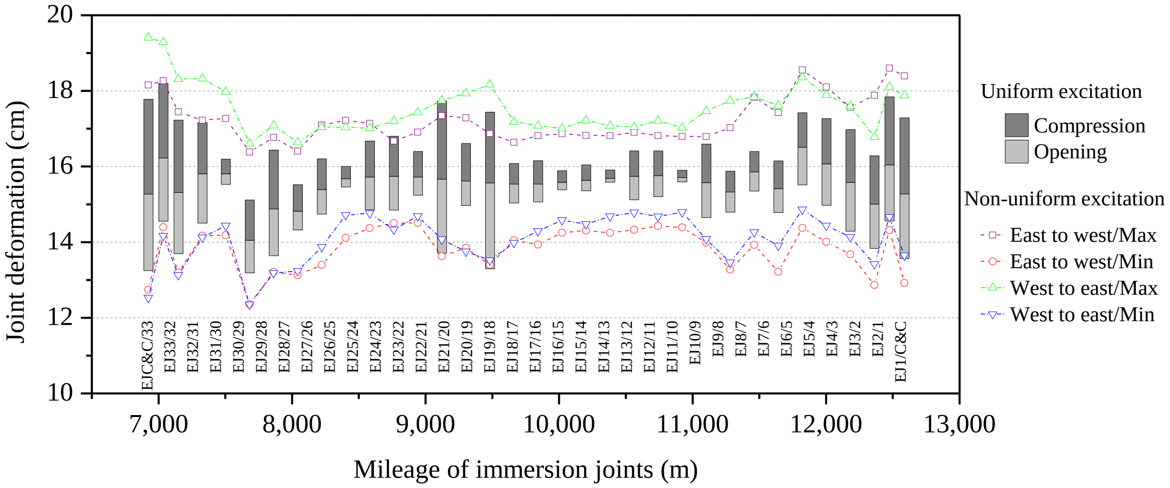

Fig.2 Longitudinal seismic deformation of the immersion joints

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